

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460**

MAR 7 1984

Mr. Dick Bruner
Executive Director
Technical and Logistics Services (DLA-S)
Defense Logistics Agency
Cameron Station
Alexandria, Virginia 22314

Dear Mr. Bruner:

This letter is in response to a number of requests made by the Department of Defense (DOD) for guidance from the Environmental Protection Agency (EPA) on the regulatory status of spent and/or discarded lithium-sulfur dioxide (Li/SO₂) batteries.

EPA recognizes that the Department of Defense has done extensive work in assessing the hazards posed by lithium batteries^{1/} and in developing procedures for managing spent or discarded Li/SO₂ cells. In fact, DOD currently considers these batteries to be hazardous wastes for management purposes. Consequently, the purpose of this letter is simply to render an Agency opinion as to whether lithium batteries are hazardous wastes under the rules promulgated pursuant to the Resource Conservation and Recovery Act of 1976 (RCRA), and to clarify the application of those rules to the management (i.e., disposal) of lithium batteries.

^{1/}The term 'lithium batteries' as used in this letter applies only to those batteries or cells commonly referred to as lithium-sulfur dioxide batteries. At this time, EPA does not have sufficient information to make a blanket determination as to whether lithium batteries using other cathode materials (i.e., thionyl chloride (SOCl₂), polycarbon monofluoride ((CF)_x), manganese dioxide (MnO₂), iodine (I), silver oxide (Ag₂O), silver chromate (Ag₂CrO₄), vanadium pentoxide (V₂O₅), iron sulfide (FeS), copper oxide (CuO), and lead bismuthate (Bi₂Pb₂O₅)) exhibit the characteristic of reactivity. Consequently, handlers of these lithium batteries must evaluate them against the reactivity characteristic identified in S261.23 as well as the other hazardous waste characteristics to determine if the batteries should be handled as hazardous wastes.

Based on a careful review of the available data and information, EPA has concluded that lithium-sulfur dioxide batteries clearly exhibit the characteristic of reactivity as defined in 40 CFR 261.23. Handlers of these wastes must, therefore, comply with all applicable standards under 40 CFR Parts 262 to 266, and 124, 270, and 271. Under these standards, the land disposal of reactive waste is prohibited unless the waste is treated or otherwise rendered non-reactive. (See 264.312 and 265.312).

Under 40 CFR 261.23, a solid waste is considered to be reactive if a representative sample of the waste has any of the following properties:

- (1) It is normally unstable and readily undergoes violent change without detonating.
- (2) It reacts violently with water.
- (3) It forms potentially explosive mixtures with water.
- (4) When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
- (5) It is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
- (6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.
- (7) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
- (8) It is a forbidden explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

The lithium in Li/So₂ cells will form potentially explosive hydrogen gas when mixed with water (261.23 (a) (3)), and Li/SO₂ cells are capable of violent rupture or reaction if subjected to a strong initiating source or if heated under confinement (261.23 (a) (6)). However, of primary concern is the potential, under existing management practices, for components of the batteries to generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment when those components are mixed with water or exposed to certain pH conditions (261.23 (a) (4) and (a) (5)).

A review of the existing literature clearly indicates that Li/SO₂ batteries are capable of violent reaction if mishandled by being exposed to a strong initiating source or heated under confinement. Incidents of violent cell ruptures, particularly of cells of the unbalanced design, have been documented in laboratory abuse tests and under actual field conditions. Although newer designs of Li/SO₂ batteries incorporate a number of safety features that reduce their explosive potential in most circumstances, forced discharge below zero volts, penetration, or heating in a confined area may still cause vented batteries to violently rupture.

Lithium-sulfur dioxide batteries typically contain strips of lithium metal as the anode as well as a non-aqueous electrolyte consisting primarily of sulfur dioxide (SO₂) and smaller concentrations of acetonitrile (CH₃CN) and a lithium salt, typically lithium bromide (Li Br). Lithium is known to react with water to produce potentially explosive hydrogen gas. Although lithium battery cells are constructed such that their reactive components do not ordinarily come into contact with water under normal operating conditions, if placed in a landfill, or otherwise improperly managed, these batteries will eventually corrode and allow their reactive constituents to come into contact with water. The reactive nature of lithium is of particular concern since substantial quantities of partially discharged cells or cells of the unbalanced, or excess lithium type, are often disposed of together. The Agency believes that under existing management practices, (i.e., storage in drums or disposal of batteries in drums), potentially explosive concentrations of hydrogen gas might reasonably be expected to occur (261.23(a) (2)).

The Agency also believes that the practice of accumulating large quantities of Li/SO₂ batteries could result in concentrations of toxic gases, vapors, or fumes in sufficient concentration to present a danger to human health or the environment. As mentioned previously, newer lithium battery cells are designed to automatically vent SO₂ and other components to the air to minimize the possibility of explosion due to pressure when the cells are exposed to external heat or short circuiting. During operations such as collection, processing, and disposal, the batteries may be exposed to mechanical shock, short circuiting, immersion in water or penetration. These operations are likely to cause cells to rupture and/or vent their reactive materials in potentially dangerous concentrations if venting or rupture occurs in a confined area or if significant numbers of cells are involved. Sulfur dioxide is a strong irritant and is capable of causing incapacitation at concentrations above 50 ppm and has proven to be life-threatening at concentrations of 400-500 ppm. In addition, acetonitrile (CH₃CN) will decompose to form toxic cyanide fumes when heated. Lithium also reacts with acetonitrile to produce lithium cyanide (LiCN) which in turn can react with weak acids to produce toxic hydrocyanic gas. Potentially dangerous concentrations of these, as well as other toxic fumes and vapors, may, therefore, be expected to result if the reactive components of these batteries are exposed to water or acidic conditions during collection, processing, or disposal operations.

The inherently reactive nature of lithium-sulfur dioxide batteries was, in fact, demonstrated by a fire at the Groton Point landfill in Groton, Connecticut on April 20, 1981. In that incident, a number of drums of lithium-sulfur dioxide batteries, which were improperly handled, caught fire due either to short circuiting or contact with

moisture. The fire resulted in a number of violent ruptures as well as the generation of toxic gases and fumes which posed a hazard to personnel combating the fire.

The Agency recognizes that the degree of hazard posed by lithium battery cells depends upon a large number of variables including:

- the quantity of cells accumulated in one location and the condition of the cells (e.g., whether they have vented, are partially depleted, fully discharged, of the balanced or unbalanced type, etc.)
- the procedures used in storing, transporting, disposing, or otherwise handling spent or discarded batteries.
- the proximity of workers or the general public to the batteries.

Due to the variable nature of the hazards posed by lithium batteries under different conditions, the Agency had considered whether it was feasible to establish accumulation levels below which quantities of lithium batteries would not be considered reactive and, therefore, not subject to the hazardous waste regulations. However, the Agency does not believe that there is sufficient information available at this time to reasonably establish such exemption levels specifically for lithium batteries.

The Agency's conclusion that lithium-sulfur dioxide batteries exhibit the characteristic of reactivity does not affect the applicability of other provisions of the hazardous waste regulations. Of specific interest to DOD may be S261.5, which conditionally exempts from hazardous waste regulation all hazardous wastes from generators that do not generate more than 1000 kg. per month of hazardous waste or accumulate more than 1000 kg. of such waste at any time.^{2/} However, you should be aware that when calculating the quantity of waste generated for purposes of assessing small quantity generator status, all hazardous wastes from all sources that are generated at a particular site^{3/} in a one-month period or which are accumulated over any period of time must be counted. You should also be aware that Congress is currently considering amendments to RCRA that would lower the small quantity generator exemption level to 100 kg.

As mentioned previously, the practical effect of the Agency's conclusion that lithium batteries are reactive wastes is that regulated quantities of these batteries may not be disposed of at most hazardous waste land disposal facilities. Sections 264.312 and 265.312 prohibit landfilling of reactive wastes unless they are treated, rendered, or mixed such that they no longer exhibit the characteristic of reactivity and unless the general requirements for reactive wastes contained in §264.17 (b) and 265.17 (b) have been met.

If you have any questions about the information contained in this letter, please do not hesitate to contact either Francine Jacoff or Robert Axelrad, of my staff at (202) 382-4761.

Sincerely yours,

/s/ Jack W. McGraw

Lee M. Thomas
Assistant Administrator

2/'Acute hazardous' wastes are subject to a 1 kg. exemption level for quantities generated in a one-month period of accumulated over any period of time. As a characteristic hazardous waste, lithium batteries are subject to the 1000 kg. exemption level.

3/See 5260.10 definitions for 'individual generation site' and 'on-site'.